US005754332A

United States Patent [19]

Crowley

[11] Patent Number: 5,754,332

[45] Date of Patent: May 19, 1998

[54] **MONOLAYER GYRICON DISPLAY**

[75] Inventor: **Joseph M. Crowley**, Morgan Hill, Calif.

[73] Assignee: **Xerox Corporation**, Stamford, Conn.

[21] Appl. No.: **713,935**

[22] Filed: **Sep. 13, 1996**

Related U.S. Application Data

[60] Provisional application No. 60/020,522, Jun. 27, 1996.

[51] **Int. Cl.**[6] **G02B 26/00**

[52] **U.S. Cl.** **359/296**; 345/107; 427/212

[58] **Field of Search** 359/296, 298; 345/107, 108, 111; 349/117, 188; 427/214, 212; 364/4, 8, 15

[56] **References Cited**

U.S. PATENT DOCUMENTS

Re. 29,742	8/1978	Tung	2/412
2,326,634	8/1943	Gebhard et al. .	
2,354,018	7/1944	Heltzer et al.	88/82
2,354,048	7/1944	Palmquist	40/135
2,354,049	7/1944	Palmquist	40/135
2,407,680	9/1946	Palmquist et al.	88/82

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

53-57998	5/1978	Japan	G09F 9/00

OTHER PUBLICATIONS

Lawrence L. Lee, "A Magnetic Particles Display", *IEEE Transactions on Electron Devices*, vol. ED 22, No. 9, Sep. 1975, pp. 758–765.

Richard A. Strain, "Additive Color Mixture with Fluorescent Pigments and Special Illumination", *Color Research and Applications*, vol. 1, No.3, Fall 1976, pp. 146–147.

N. K. Sheridon and M. A. Berkovitz, "The Gyricon—A Twisting Ball Display", *Proceedings of the S. I. D.*, vol. 18/3 & 4, 1977, pp. 289–293.

A. Chiang, D. Curry and M. Zarzycki, "A Stylus Writable Electrophoretic Display Device", *S. I. D. 79 Digest*, 1979, pp. 44–45.

(List continued on next page.)

Primary Examiner—Loha Ben

Attorney, Agent, or Firm—Alexander E. Silverman

[57] **ABSTRACT**

A gyricon or twisting-ball display having superior reflectance characteristics comparing favorably with those of white paper. The display is based on a material made up of optically anisotropic particles, such as bichromal balls, disposed substantially in a monolayer in a substrate. The particles are closely packed with respect to one another in the monolayer, preferably so that adjacent particle surfaces are as close to one another as possible. A rotatable disposition of each particle is achievable while the particle is thus disposed in the substrate; for example, the particles can already be rotatable in the substrate, or can be rendered rotatable in the substrate by a nondestructive operation performed on the substrate. In particular, the particles can be situated in an elastomer substrate that is expanded by application of a fluid thereto so as to render the particles rotatable therein. A particle, when in its rotatable disposition, is not attached to the substrate. A reflective-mode display apparatus can be constructed from a piece of the material together a mechanism (e.g., addressing electrodes) for facilitating rotation of at least one of the particles. The light reflected from the display is reflected substantially entirely from the monolayer of balls, so that lower layers are not needed. By eliminating the lower layers, the display can be made thinner, which in turn provides further advantages, such as lower drive voltage and better resolution due to better control of fringing fields.

31 Claims, 18 Drawing Sheets